Volume 9 FEBRUARY 7, 1934 No. 1

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM

FOR THE

NEW YORK MEETING

FEBRUARY 23–24, 1934

JOINT MEETING

WITH THE

OPTICAL SOCIETY OF AMERICA

COLUMBIA UNIVERSITY

For Program of session of the Optical Society see Pages 5 to 8
For Program of sessions of the Physical Society see Pages 9 to 17

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The American Physical Society

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of the

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FEBRUARY 7, 1934 Vol. 9, No. 1

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

NEW YORK MEETING, FEBRUARY 23–24, 1934

JOINT MEETING WITH THE OPTICAL SOCIETY OF AMERICA

THE 190th regular meeting of the American Physical Society will be held in New York City on Friday and Saturday, February 23–24, 1934 as a joint meeting with the Optical Society of America. The sessions on Friday and Saturday for both the Physical Society and the Optical Society will be held at Columbia University in the Physics Laboratories, on 120th Street east of Broadway (entrance at 119th Street and Broadway).

Joint Session. On Friday morning at 9:30 o'clock there will be a joint session of the two Societies in Room 401. This session will be a symposium on *Measuring Spectral Radiation.* The President of the Optical Society, Dr. W. B. Rayton of the Bausch and Lomb Optical Company will preside.

Regular Sessions. For details of the regular sessions of contributed papers see the Calendar in the following pages.

Dinner. On Friday evening at 6:30 o'clock there will be a joint dinner for the members of the two Societies and their friends at the Columbia University Men's Faculty Club (corner 117th Street and Morningside Drive). The President of the Physical Society, Professor Arthur H. Compton of the University of Chicago will preside. The price of the dinner will be $1.25 per plate. Tickets will be on sale at the Physics Laboratories, Columbia University. Reservations should be made as early as possible and not later than Friday at 3 P.M. The time of the dinner is set early so that those who wish may leave in time for other evening appointments.

Luncheon. On Friday and Saturday luncheon may be had at the Columbia University Men's Faculty Club. Further announcement will be made at the Friday and Saturday sessions.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. In the case of a paper with joint authors the paper will be assigned to the author whose name appears first.

Papers received after the program has been printed will be placed in the supplementary program. The presiding officer may in his discretion call for such papers to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

The supplementary papers may be called for at the end of any regular session in Room 401.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts of the Physical Society papers will be published in the

Physical Review and those of the Optical Society papers in the Journal of the Optical Society of America. Authors should send corrections to the editors of the respective journals.

Other meetings for the current season are as follows:

191. Washington. April 26–28, 1934.
192. Berkeley, California. June 18–23, 1934.
193. Summer meeting in the East. Time and place to be announced later.
194. St. Louis, Missouri. November 30–December 1, 1934.
195. December 1934. Pacific Coast. Time and place to be announced later.
196. Annual Meeting. Pittsburgh. December 27, 1934–January 2, 1935.

W. L. SEVERINGHAUS, *Secretary*,
Columbia University, New York, N. Y.

February 7, 1934.

CALENDAR

Friday morning

9:30 o'clock: Physics Laboratories: Room 401: Joint session of the two Societies: Symposium on "Measuring Spectral Radiation." Papers 1–6. See page 5.

Friday afternoon

2:00 o'clock: Physics Laboratories: Room 428, Optical Society Papers 7–13. See page 5.

2:00 o'clock: Physics Laboratories: Room 401, Physical Society Papers 7–15. See pages 9–11.

4:00 o'clock: Physics Laboratories: Room 818, Meeting of the Council of the Physical Society.

Friday evening

6:30 o'clock: Columbia University Men's Faculty Club: Joint dinner of the two Societies.

Saturday morning

10:00 o'clock: Physics Laboratories: Room 428, Optical Society Papers 14–17. See pages 6–7.

10:00 o'clock: Physics Laboratories: Room 401, Physical Society Papers 16–22. See pages 11–12.

10:00 o'clock: Physics Laboratories: Room 329, Physical Society Papers 23–32. See pages 13–14.

Saturday afternoon

2:00 o'clock: Physics Laboratories: Room 428, Optical Society Papers 18–21. See pages 7–8.

2:00 o'clock: Physics Laboratories: Room 401, Physical Society Papers 33–41. See pages 14–16.

THE OPTICAL SOCIETY OF AMERICA

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PROGRAM

FRIDAY, FEBRUARY 23 AT 9:30 O'CLOCK

Room 401

Joint Session of the American Physical Society and the Optical Society of America

Joint Session of the American Physical Society and the Optical Society of America

SYMPOSIUM ON

MEASURING SPECTRAL RADIATION

1. **Fundamental Principles.** W. E. FORSYTHE, *General Electric Company.* 20 minutes
2. **Methods of Obtaining Spectral Radiation.** HENRY KURTZ, *Bausch & Lomb Optical Company.* 20 minutes
3. **Measuring Energy with Blackened Receivers.** C. G. ABBOT, *Smithsonian Institution.* 20 minutes
4. **Measuring Energy with Photographic Plate.** BRIAN O'BRIEN, *University of Rochester.* 20 minutes
5. **Measuring Energy with Photoelectric Tube.** L. R. KOLLER, *Bureau of Standards.* 20 minutes
6. **Visual Measurements (Spectrophotometry).** K. S. GIBSON. *Bureau of Standards.* 20 minutes

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FRIDAY, FEBRUARY 23 AT 2:00 O'CLOCK

Room 428

Invited Papers

on

MEASURING SPECTRAL RADIATION

(For simultaneous session of the Physical Society, Room 401, see Program, pages 9–11.)

7. **Sources of Radiation.** A. G. WORTHING, *University of Pittsburgh.*
8. **Analysis of Radiation by Gratings.** R. C. GIBBS, *Cornell University.*
9. **Optical Features of the Spectrometer.** B. T. BARNES, *General Electric Company.*
10. **Slit Width Corrections.** W. W. WENIGER, *Oregon State College.*
11. **Methods of Blackening Receivers and Amplification of Galvanometer Reflections.** A. H. PFUND, *The Johns Hopkins University.*
12. **Radiometers and Radiomicrometers.** B. J. SPENCE, *Northwestern University.*
13. **Ultraviolet Spectrometer and Densitometer.** G. R. HARRISON, *Massachusetts Institute of Technology.*

Saturday, February 24 at 10:00 O'clock

Room 428

Contributed Papers

(For simultaneous sessions of the Physical Society, Rooms 401 and 329, see Program, pages 11–14.)

14. An Eyepiece for Measuring the Amount of Plane Polarization in a Beam of Light. Fred E. Wright, *Geophysical Laboratory, Carnegie Institution of Washington.* (15 minutes.)

With this eyepiece the plane polarization in a beam of light is compensated by means of a plane-parallel plate of glass or of celluloid tilted at the proper angle. The test, to ascertain if the compensation is complete, is made by means of a biquartz plate and a second tiltable plate in combination with a Savart plate and nicol or Wollaston prism. The biquartz plate is 1.76 mm thick and consists of two plates of quartz cut normal to the optic axis, the one of dextrogyre, and the second of levogyre quartz, mounted side by side with a vertical junction face. For mercury green light of wave-length 5461A, the rotation is ±45°. An incident plane polarized beam is divided into two beams such that the plane of vibration of the one in the first half of the biquartz plate is normal to that of the other beam in the second half. The second plane-parallel, tiltable plate is mounted above the biquartz plate with its axis of rotation in the plane of vibration of the wave emerging from one of the biquartz plate halves. By means of this tiltable plate a small amount of polarization may be added to, or subtracted from, the polarization in the transmitted beams. This second tiltable plate was first used by B. Lyot in his analysis of the light from the moon and the planets. The Savart plate and analyzing prism are employed to indicate the presence of polarized light in the beam. During the past year the eyepiece has been used chiefly in the measurement of the percentage polarization of light reflected by different parts of the moon's surface and by terrestrial materials. It has also been employed for the measurement of sky polarization and in metallographic work. It serves well both for monochromatic and for natural light. With it the amount of plane polarization can be determined, for low percentages, to one-tenth of one percent.

The present paper will appear in full in Journal Optical Society of America.

15. A New Recording Color Analyzer. Arthur C. Hardy, *Massachusetts Institute of Technology.* (25 minutes.)

A recording photoelectric spectrophotometer employing the null method was described in a previous communication.[1] The new instrument, which has been in constant use for more than a year, utilizes the same basic principles with an improved optical system. The present system consists of a double monochromator, which is followed by a photometer unit consisting of two Rochon prisms and a Wollaston prism. The Wollaston prism separates the beam leaving the monochromator into two beams, one of which falls on the sample and the other on the standard. The Rochon prism behind the Wollaston prism is rotated at high speed to produce the alternation of the two beams required by the null method. The Rochon prism ahead of the Wollaston prism is used like the nicol in a Martens photometer to control the relative intensity of the two beams. Since both beams traverse the same optical parts, the effect of selective absorption or selective reflection is completely eliminated. Due to the employment of the null method, the readings are not affected by variations in the light source, the photoelectric cell, or the associated amplifier.

[1] J.O.S.A. and R.S.I. **18**, 96 (1929).

16. A Photoelectric Colorimeter and Its Application to Grading Rosin. Brooks A. Brice, *Food and Drug Administration, U. S. Department of Agriculture.* (15 minutes.)

A null method photoelectric colorimeter possessing the advantages of low cost, portability, ease and rapidity of operation, high precision, and direct reading of percent transmission, has been developed for grading rosin and is applicable to other color problems.

It consists essentially of a lamp, pairs of color filters, two Weston Photronic cells connected in opposing parallel, a galvanometer, a rheostat potentiometer equipped with a dial reading from 0 to 100, and a compensating resistance which makes the dial read percent transmission directly. The value of the compensating resistance depends on the characteristics of the photo-cells and on the magnitude of the currents and resistances in the circuit, and was found experimentally by obtaining dial readings on a set of wire screens of known transmissions. It is apparently possible, by proper selection of photo-cells and resistances, to make the accuracy of the dial readings equal to the accuracy of the known screen transmissions. The reproducibility of readings is about 0.2 division of the dial scale.

Visually, the grade of a rosin sample is decided by comparing its color (chromaticity and brightness) with that of a glass color standard, brightness being involved because of the presence of fine dirt in commercial gum rosin. Disagreements even between experienced observers are frequent. With the photoelectric apparatus, the green transmission G and the red transmission R of the rosin sample are measured by balancing the circuit using blue-green and red filters. The ratio G/R is taken as a measure of the chromaticity of the sample, and a tentative empirical relation $G/(R+10)$ gives a color index which weighs brightness with chromaticity in good agreement with best accepted visual grading.

17. Standardization of Lovibond Red Glasses. K. S. Gibson and Geraldine K. Walker, *Bureau of Standards.* (20 minutes.)

The method of standardization of the Bureau's Lovibond

red glasses was briefly indicated in a previous abstract.[1] Over 2000 red glasses have now been calibrated in terms of the Priest-Gibson (N″) scale and unit which were established in 1927. Results on the first 1000 glasses[2] will be illustrated.

Further study of the N″ scale has been made, including extensive comparisons of values of N″ derived both from spectral transmission and from direct comparison with the Bureau's standard glasses. The additive and consistent nature of the N″ scale has been confirmed by this study.

The present paper will appear in full in Bur. Standards J. Research.

[1] Irwin G. Priest and K. S. Gibson, *Standardising the Red and Yellow Lovibond Glasses*, J.O.S.A. & R.S.I. **16**, 116 (1928).

[2] Geraldine K. Walker, *Statistical Investigation of the Uniformity of Grades of 1000 Lovibond Red Glasses*, Bur. Standards J. Research **12**, March, 1934.

Saturday, February 24 at 2:00 O'clock

Room 428

Contributed Papers

(For simultaneous session of the Physical Society, Room 401, see Program, pages 14–17.)

18. The Basis for Wave-Length Discrimination by the Color-Blind. Selig Hecht and Simon Shlaer, *Columbia University*. (25 minutes.)

Measurements with two deuteranopes and one protanope show that, when brightness differences are eliminated, wave-length discrimination is practically absent at both ends of the spectrum, and exists only in a band between 470 and 570 mμ. Both edges of this discrimination band are fairly sharp; the short wave edge is at 470 for all three observers; the long wave edge varies between 550 and 570 at different times for the different observers.

The distance in wave-length which must separate two wave-lengths for them to be recognized as different when brightness differences are eliminated is a minimum at the neutral point, and increases exponentially with the distance from the neutral point. The function is not symmetrical about the neutral point, because the values on the long wave side rise more slowly than on the short wave side.

The basis on which the color blind discriminates wave-length on each side of the neutral point is relative saturation. The short wave stretch of the spectrum up to the neutral point is matched by mixtures of 440 mμ and white of color temperature 5000°K. Similarly the stretch between the neutral point and 700 mμ is matched by mixtures of white and 650 mμ. For example, to match 490 mμ the protanope whose neutral point is 491.5, requires a brightness ratio (measured by himself) of white to 440 mμ of nearly 1000; for 485 it drops sharply to 100; for 480 it is 10; and for 475 it is 1. Similarly to match 492 the brightness ratio of white to 650 mμ is about 150; for 495 it drops to 1; for 510 to 0.1; and for 570 to 0.01. To the color-blind the spectrum is thus two hues which increase in saturation from the neutral point outwards.

In view of the wave-length discrimination of color-blinds, their previously recorded color mixture equations cannot be considered unique except near the neutral point. Elsewhere the equations are in part determined by the relative brightness of the measuring primaries. Our measurements confirm this conclusion.

The present paper will appear in full in The Journal of General Physiology.

19. A Maxwell Triangle Yielding Uniform Chromaticity Scales. Deane B. Judd, *Bureau of Standards*. (20 minutes.)

The length of a line on the Maxwell triangle of the I.C.I. coordinate system for colorimetry[1] is an approximate index of the chromaticity difference between the stimuli represented at the extremes of the line; the O.S.A. coordinate system also has this property, and to about the same degree of approximation.[2] However, sufficient data on chromaticity sensibility have now been gathered to show that the Maxwell triangle of both systems can be improved upon in this respect. It has been found possible to effect very marked improvement, so much so that the new coordinate system has been called the "uniform-scale system" because it is so closely true that uniform chromaticity scales may be derived from it merely by stepping off equal intervals on the Maxwell triangle. The agreement of scales so derived with extant data on chromaticity sensibility will be shown graphically. This includes sensibility to wave-length change in the spectrum and at colorimetric purities less than one, sensibility to purity change for various purities and dominant wave-lengths, and sensibility to color-temperature change.

An important application of this coordinate system is its use in finding from any series of chromas the one most resembling any other given chroma, for example, the finding of the nearest color temperature for any non-Planckian stimulus.[3] The method, of course, is to draw the shortest line from the point representing the non-Planckian stimulus to the Planckian locus.

It should be noted that the coordinate system derived is not the only one which will yield a uniform-scale triangle. The area representing real stimuli may be uniformly expanded or contracted, moved about the triangle, or reoriented without injuring the agreement with sensibility data. On this account, there is promise that it can be

[1] Judd, *The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry*, J.O.S.A. **23**, 359 (1933).

[2] Judd, *Chromaticity Sensibility to Stimulus Differences*, J.O.S.A. **22**, 72 (1932).

[3] Davis, *A Correlated Color Temperature for Illuminants*, Bur. Standards J. Research **7**, 659 (1931).

incorporated into many of the theories of vision such as that of Hering, or the Hecht development of the Young-Helmholtz theory, or the zone theory of G. E. Müller.

20. The Scattering of Infrared Radiations by Small Particles. A. H. PFUND, *Johns Hopkins University.* (15 minutes.)

The scattering by transparent particles is inferred from transmission measurements. Experiments on transmission were carried out in the infrared since here the wave-length may be made large in comparison with particle-size (Rayleigh condition for scattering). Zinc-oxide pigments of known particle-size, ranging in diameter from 0.09 to 0.4 microns and completely dispersed in rubber and xylene, were studied in the spectral region 0.5 to 2.7μ. Dry pigment films could be investigated to 7μ and beyond. Following are the results:

1. The transition from non-selective reflection to scattering sets in when the wave-length is about equal to the particle-diameter.

2. Rayleigh's inverse fourth-power law was verified for the rubber dispersion of zinc-oxide (0.09 micron diameter) over the spectral range 0.8 to 2.4μ.

3. By taking known mixtures of particles having diameters of 0.09 and 0.4 micron, respectively, transmission curves were obtained. These led to the conclusion that a statement of the average particle diameter is insufficient to define the pigment uniquely.—However, by imposing the two conditions (1) that the average diameter have a definite value, (2) that the transmission curve be of definite form, a closer approach to specification of the pigment is realized. For this work it is necessary that the transmission curves be obtained in a spectral range within which the wave-lengths are too small to enable Rayleigh's law to apply.

4. By proceeding to a region of greater wave-length where Rayleigh's law holds, it becomes theoretically possible to evaluate the refractive index of particles which are below the limit of resolution of the microscope.

The present paper will appear in full in Journal of Optical Society.

21. Luminescence of Thorium Oxide Activated by Rare Earths. Optimum Concentration for Different Sources of Excitation. FRANCES G. WICK AND CHARLOTTE G. THROOP, *Vassar College.* (10 minutes.)

Thorium oxide containing a small amount of a rare earth is luminescent under different sources of excitation, the intensity of luminescence varying with the concentration of the rare earth. Three sets of specimens were prepared containing as activators praseodymium, samarium, and terbium in concentrations varying by known amounts and including such as were above and below that that required for optimum brightness. Identical methods of preparation and subsequent heat treatment were used for the different specimens. The only difference in the specimens of a group was that of concentration of the rare earth. The concentrations of praseodymium used varied from 1 atom of praseodymium to 100 molecules of thorium oxide to 1 atom to 100,000 molecules; those of samarium from 1 atom in 15.5 molecules to 1 atom in 2000 molecules; those of terbium from 1 atom in 10 molecules to 1 atom in 40,000 molecules.

By means of an optical pyrometer the intensity of fluorescence each of the specimens of varying concentration of a rare earth was measured when the source of excitation was cathode rays, when it was ultraviolet light and when it was the hydrogen flame. From these observations the concentration of rare earth required for maximum intensity under each of these sources—the "optimum concentration"—was determined. The "optimum" is widely different when different sources of excitation are used.

The results of the observations upon thorium oxide with the three different rare earths as activators are shown in the following table which gives the concentrations required for most intense excitation—the "optimum concentration."

	Source of Excitation (Molecules of ThO_2 per atom)		
Activator	Cathode rays	Hydrogen flame	Ultraviolet
Terbium	389	158.5	69.18
Samarium	69.18	23.44	48.98
Praseodymium	489.8	263.	346.7

PROGRAM

For Sessions of the American Physical Society

FRIDAY MORNING AT 9:30 O'CLOCK

Room 401

Joint Session of The American Physical Society
and The Optical Society of America

SYMPOSIUM ON

MEASURING SPECTRAL RADIATION

Invited Papers

1. **Fundamental Principles.** W. E. FORSYTHE, *General Electric Company.* 20 minutes
2. **Methods of Obtaining Spectral Radiation.** HENRY KURTZ, *Bausch & Lomb Optical Company.* 20 minutes
3. **Measuring Energy with Blackened Receivers.** C. G. ABBOT, *Smithsonian Institution.* 20 minutes
4. **Measuring Energy with Photographic Plate.** BRIAN O'BRIEN, *University of Rochester.* 20 minutes
5. **Measuring Energy with Photoelectric Tube.** L. R. KOLLER, *General Electric Company.* 20 minutes
6. **Visual Measurements (Spectrophotometry).** K. S. GIBSON, *Bureau of Standards.* 20 minutes

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FRIDAY AFTERNOON AT 2:00 O'CLOCK

Room 401

(For simultaneous session of the Optical Society, Room 428, see Program, pages 5 to 8.)

Paper No. 8 will be read by title.

7. On the Redward Shift of the Spectral Lines of Nebulae. P. I. WOLD, *Union College, Schenectady, N. Y.*—The redward shift of spectral lines from nebulae has been interpreted, by Doppler's principle, in terms of a recession of the nebulae and an expanding universe. The idea of such a universe has not been wholly pleasing to some and attempts have been made to find other explanations. If one assumes that the velocity of light throughout space is a function of time, and in particular has been slowing down over a long period, then one can account for the redward shift without resorting to recession. This slowing up of velocity is not related in any way to DeBray's suggestion of a few years ago or the recent cyclical variations found in Pasadena, but is of a very much smaller magnitude. Assuming, as a simple case, that the velocity is a linear function of time, given by $c_1=c(1-\alpha t)$, and taking the measurement of shift by Hubble and Humason the coefficient comes out as $\alpha=5.72\times10^{-10}$ with the year as unit of time and $\alpha=1.81\times10^{-17}$ with the second as unit of time. If this rate of decrease were to continue, then the velocity of light would be zero after about 1.7×10^{9} years. It is not likely, however, that the decrease would continue indefinitely but rather that it would be periodic in nature. It is recognized that, for the present at least, the weakness of the speculation here suggested is its high degree of *adhocness* but certain experiments suggest themselves which may alter this.

8. A Relation Between Internuclear Distances and Bond Force Constants. RICHARD M. BADGER, *Gates Chemical Laboratory, California Institute of Technology.*—It has been found that for diatomic molecules the relation between the internuclear distance r_e and the bond force constant k_0 (calculated from the relation $\omega_e c=(\frac{1}{2}\pi)\sqrt{k_0/\mu}$) is quite accurately given by the expression $k_0(r_e-d_{ij})^3=C$. The constant C is the same for all molecules and the constant d_{ij} depends only on the rows in the periodic table in which the two elements comprising the molecule are located. The expression holds for the normal states and for all excited states, with a few possible exceptions, and is much more reliable than previously proposed expressions relating ω_e and r_e. Uses of the relation are discussed, and values for the constants are given in a paper to appear shortly.

9. Possible Models of an Electrostatic Neutron. HENRY MARGENAU, *Yale University.*—Calculations have been

made regarding the possibilities of forming a stable structure consisting of a stationary proton and an electron, admitting a deviation of the potential from Coulomb form near the origin. The assumption is that at some distance r_0 from the origin the electron encounters either a potential barrier or a trough of finite height $\Delta\varphi$. We regard as an admissible eigenfunction one which satisfies the usual conditions at $r=0$ and $r=\infty$, and, in addition, behaves properly at r_0. Solutions are found by assuming a value of the binding energy$\sim mc^2$, integrating the wave equation from ∞ inward numerically, and then determining the value of $\Delta\varphi$, for any given r_0, which makes ψ finite at the origin.—Results on basis of Schrödinger's theory are discussed, but are shown to be objectionable. Using Dirac's theory, one can produce stability for any value of r_0 (smaller than the classical electron radius), *provided the binding energy is not larger than 2 mc²*. $\Delta\varphi=0$ is excluded. A particularly interesting model results if we assume the proton to be classically impenetrable (potential wall of great height at r_0). ψ-functions for this case are discussed. The electron is bound essentially by its quasi-electric moment which is drawn into the strong field about r_0. Its average spin is 0, so that the spin of the neutron is that of the proton alone.

10. Atomic Energy Relations. R. F. BACHER AND S. GOUDSMIT, *University of Michigan.*—The electrostatic interaction between electrons of many electron atoms is treated in a new way. The method employed by the authors is based on the same principles as Slater's treatment of this problem. It differs from Slater's theory first of all by expressing the interaction in terms of the energy states of the two-electron spectrum instead of expanding it in the usual radial integrals. This modification has several advantages. Its principal advantage is the simplicity with which the method can be extended to include higher approximations. This is done by considering not merely the interaction as revealed by the two-electron ion, but by including also the information obtainable from the three-, four- and more-electron spectra of the same atom. The formal procedure, as usual in such problems, involves simple manipulations with "Pauli tables." The results finally appear in the following form: A particular atomic energy state is expressed in terms of various energy states which occur in the ions of this atom, the degree of approximation depending on the number of ions included. A typical expression of this sort is that for $sp^3\ {}^5S$.

$$(sp^3)^5S=(p^3)^4S^0+3(sp^2)^4P-3(p^2)^3P$$
$$-3(sp)^3P^0+3(p)^2P^0+(s)^2S.$$

The calculated and observed absolute values for the multiplets of sp^3 in O III are:

	^5S	^3S	^3D	^3P	^1P	^1D
cal. 382399 cm^{-1}	244756	322806	301429	232518	253862	
obs. 382912 cm^{-1}	245720	322768	300420	232348	255757	

These values are obtained directly from the energies of O IV, O V and O VI as observed by Edlén (Zeits. f. Physik **84**, 746 (1933)) without any adjustable constants.

11. Numerical Solution of Eigenvalue Problems in any Number of Dimensions. G. E. KIMBALL AND G. H. SHORTLEY, *National Research Fellows Massachusetts Institute of Technology.*—A differential equation whose solutions are subject to given conditions on the boundary of a region is approximated to any desired accuracy by a set of difference equations over a lattice covering the region. Two quadratic forms in the function values at the lattice points are found, whose ratio W is a minimum for the lowest state of the difference problem, and approximates the variational integral of the differential problem. A method is developed for calculating rapidly the exact solutions of the difference equations by changing the value of a rough solution at each lattice point in turn in such a way as always to decrease W. For higher states the variation is made subject to orthogonality side-conditions of the usual type. The method is being applied to the solution of Schrödinger's equation for an electron in an arbitrary axially symmetric field such as occurs for diatomic molecules. This problem is conveniently handled in cylindrical coordinates, the singularity of the axis causing no particular difficulty.

12. Indeterminacy Relations in Some Special Problems. F. E. WHITE AND R. B. LINDSAY, *Brown University.*—De Broglie has obtained indeterminacy relations using trains of plane waves. The present paper generalizes these to the case of (a) spherical waves and (b) waves of general type in which the velocity of the point of phase agreement normal to the wave surfaces is constant. The work of Remak is extended by finding higher order indeterminacy products. Thus, e.g., for the harmonic oscillator $(\Delta x)^4(\Delta p_x)^4=h^4/256\pi^4\cdot(6n^2+6n+3)^2$, while $(\Delta x)^3(\Delta p_x)^3=0$. For the oscillator in a uniform field ($V=\frac{1}{2}kx^2-k\alpha x$) there results $(\Delta x)^2(\Delta p_x)^2=\{(2n+1)h/4\pi\}^2+m_0v_0h\alpha^2$. The case of the anharmonic oscillator ($V=\frac{1}{2}kx^2+k\alpha x^3$) is handled by evaluating the eigenfunctions by the perturbation method. It is found that the latter can be expressed in terms of Hermite polynomials of order n, $n+1$, $n-1$, $n+3$, and $n-3$. The indeterminacy relation to terms in α^2 is

$$(\Delta x)^2(\Delta p_x)^2=\{(2n+1)h/4\pi\}^2+\alpha^2h^3(2n+1)(328n^4$$
$$+656n^3+650n^2+322n+123)/2304\pi^4m_0v_0.$$

In the limit of $\alpha\doteq 0$ these results approach that for the harmonic oscillator.

13. Elastic Wave Analogies of the Motion of Electrons in Force Fields. R. B. LINDSAY, *Brown University.*—In the one dimensional motion of an electron (total energy $W>0$) through a rectangular potential "hollow" of width l and depth V_0, the wave-mechanical probability of transmission is

$$\left[\cos^2\alpha_2 l+\frac{1}{4}\left(\frac{\alpha_1}{\alpha_2}+\frac{\alpha_2}{\alpha_1}\right)^2\sin^2\alpha_2 l\right]^{-1},$$

with $\alpha_1=\left[(8\pi m_0/h^2)W\right]^{\frac{1}{2}}$ and $\alpha_2=\left[(8\pi m_0/h^2)(W+V_0)\right]^{\frac{1}{2}}$. In the passage of a plane harmonic compressional (acoustic) wave in a fluid through an infinite tube of cross sectional area S_1 in which there is an abrupt constriction or expansion of length l and cross section S_2, the power transmission

ratio is

$$P_r=\left[\cos^2 kl+\tfrac{1}{4}(S_2/S_1+S_1/S_2)\sin^2 kl\right]^{-1}.$$

The indicated analogy becomes even more striking if the fluid in the expansion or contraction has a different density from that in the rest of the tube. Similarly in the motion of an electron through an infinite one dimensional crystal lattice for which the potential energy variation is represented by a rectangular saw-tooth curve (the potential energy alternating between V_1 and V_2) the criterion for the passage of the electron through the lattice or its complete reflection, in the case where $W>$ both V_1 and V_2, can be shown to be completely analogous to that for transmission or attenuation in an infinite elastic wave filter consisting of a series of alternating layers of two different media (either solid or fluid) with a possible alternation of area of cross section. The analogy breaks down if $W>V_1$ but $W<V_2$.

14. A New Transformation Theory of Linear Canonical Equations. CORNELIUS LANCZOS, *Department of Mathematics, Purdue University.*—The ordinary transformation theory of Hamilton-Jacobi is not adapted to the nature of linear canonical equations, in which case the Hamiltonian function $H(q_k p_k)$ is a quadratic form of the variables $q_k p_k$ and the solution of the partial differential equation of Hamilton-Jacobi involves irrational operations. Instead of that we may ask for linear canonical transformations which bring the quadratic form into a normal form. This normal form turns out to be $\Sigma\lambda_k p_k q_k$ an analogy to the normal form $\Sigma\lambda_k q_k^2$ of the ordinary transformation theory of quadratic forms which use orthogonal instead of canonical transformations. In the normal reference-system the canonical equations are separated and can be integrated immediately. The transformation into the normal form requires no integrations but only algebraic processes. The solution is only approximate since the transformation modifies the Hamiltonian function. A repetition of the procedure is possible, thus approximating the normal form closer and closer. Since any self-adjoint differential equation or sets of such equations can be brought into the canonical form, this theory provides an approximate solution of any self-adjoint system. In the case of a self-adjoint equation of second order the first approximation is identical with well-known approximate solution of Wentzel-Kramers-Brillouin.

15. Calculation of the Total Probability of Excitation by Electron Impact. F. E. NULI, *College of the City of New York.*—Since little is known concerning the combined probability of excitation by electron impact of all energy levels of the atom, it is interesting to calculate the variation of the total excitation probability with the mean kinetic energy of the exciting electrons. Two simple equations have been applied to the region of electron energy below forty equivalent volts. One equation is the statement of the conservation of energy in a region in which an electron cloud is drifting in an electric field. The other equation equates the ionization produced by electron impact to the product of the number of collisions and the mean probability of ionization per collision as determined by the mean kinetic energy of the electron cloud. The equations give the approximate value of the combined probability of excitation by electron impact of all energy levels. This combined probability plays an important part in the theory of electrical discharges in gases. The equations may be applied to the velocity of drift of an electron avalanche, which is involved in the theories of the mechanism of the spark as given by von Hippel and Franck and by L. B. Loeb.

SATURDAY MORNING AT 10:00 O'CLOCK

Room 401

(For simultaneous session of the Optical Society, Room 428, see Program, pages 6–7.)

16. Absorption of Oxygen in the Extreme Ultraviolet. G. B. COLLINS AND W. C. PRICE, *The Johns Hopkins University. (Introduced by R. W. Wood.)*—Absorption bands of oxygen below 1000A, first noticed by Hopfield, were photographed with a 2 m concave grating at grazing incidence. The continuous spectrum was furnished by a Lyman explosive discharge through a glass capillary. It seems certain that the bands are due to normal oxygen. There was always active oxygen in the spectrograph but control experiments indicated that the possibility that the bands are due to O_2^+ or Ozone could be excluded. The strongest bands could be arranged into three progressions with the formulae (in cm^{-1})

$$99\,144+1056(v+1/2)$$
$$100\,906+1127(v+1/2)-17(v+1/2)^2$$
$$105\,863+913\ (v+1/2)$$

The numbering of the last progression is uncertain. More than 50 bands were measured at shorter wave-lengths and will be given in a later communication. About 25 bands between 1210 and 1000 were found. They do not form any pronounced sequences and their interpretation is still uncertain.

17. Ultraviolet Absorption of Iodine. DANA T. WARREN, *Yale University.*—Three new lines of evidence show that all the absorption bands of iodine lying between 1765 and 2840A (Jevons *C* and *C'*), discovered by Pringsheim and Rosen, Kimura and Miyanishi, and Sponer and Watson, form a single system. First is the regularity of the development of the bands with temperature and pressure. Second the ease and completeness of overlapping of the regions of different investigators. Thirdly the "long thin bridge" at 2150A is explained as the result of the coincidence of a

frequency of 210 cm^{-1} in the ground state and 70 cm^{-1} in the upper state, causing all progressions to coincide. Many new bands have been found, but vibrational assignments are impossible with the present accuracy, which cannot be improved merely by measurement. Even the use of a microphotometer is helpful only where the system is simple. Two new band systems of iodine impurities, one between 1960 and 2223A, the other at high temperatures between 2700 and 3300A, discovered in this investigation are being further studied.

18. Nitrogen Molecular Spectra in the Vacuum Ultraviolet. WILLIAM W. WATSON AND PHILIP G. KOONTZ, *Yale University.*—With a high current discharge in flowing nitrogen gas as the source, spectrograms covering the interval 2300A to 1000A have been taken with a 10-foot vacuum spectrograph; dispersion 5.5A/mm. Quantum assignments have been made for many rotational lines of the (0, 1), (0, 4), (1, 5), (1, 6), (1, 7), and (2, 8) bands of the $a \rightarrow X$ system, (0, 14), (0, 15) and (0, 16) of the $b' \rightarrow X$ system, and (0, 12) of the $c \rightarrow X$ system. For $a\ ^1\Pi_u$, $B_0 = 1.632 \pm 0.002$, while for $X\ ^1\Sigma_g^+$, $B_0 = 1.998 \pm 0.002$. The b' system consists of a progression of singlet Q branches, each $Q(25)$ line displaying an intensity perturbation. The b' state is thus $^1\Pi_u$ with $v=0$, for which $R_0 = 1.147$. Measurement of the strong lines in the $c12$ band indicate a Q branch with $B_0' = 1.159$. Levels with $v > 9$ do not occur in $a\ ^1\Pi_u$. If $D = 7.9$ volts for the normal $^1\Sigma_g^+$ state, $v=9$ of $a\ ^1\Pi_u$ coincides with the sensitive $v=13$ level of $B\ ^3\Pi_g$ at the energy of dissociation into $^4S + ^2D$ atoms. Also, $v=0$ of the b, b' and c states and $v_{max} = 5$ of the $C\ ^3\Pi_u$ state come at the energy for dissociation into $^2D + ^2P$ atoms. These facts support the value $D = 7.9$ volts for N_2 (W. W. Lozier, Phys. Rev. **44**, 575 (1933)). Discussion of the various N_2 levels and transitions is included.

19. Intensity Relations in Hyperfine Structure of Optically Excited Mercury Line λ5461. EMILY E. BOGGS AND HAROLD W. WEBB, *Columbia University.*—The relative intensitives of the h.f.s. components of λ5461 in optically excited mercury vapor were computed by using the energy level scheme and intensity distribution given by Schuler and Keyston (Zeits. f. Physik **72**, 423 (1931)), with the assumption that λ2537 is completely absorbed and λ4358 very slightly. Since the excitation is in two steps the ratio of the intensities of the components due to the less abundant isotopes to those due to the more abundant is much less than in the normal low pressure arc, in which excitation of each isotope is proportional to its concentration. These results were checked experimentally by using a Lummer plate. Excitation was by a low pressure quartz arc supplemented by two glass arcs to increase the intensity of λ4358. The quartz and glass arcs gave intensity distributions agreeing well with those of Schuler and Keyston, which indicate small reversal. From the optically excited vapor the relative intensities agreed within experimental error with the values computed as above. For example, the ratio of the intensity of the central component to that of the −0.278 component was found to be six times greater than in the normal arc. Pool and Simmons (Phys. Rev. **44**, 744 (1933)) find this to be less than four. Similar measurements are being made on λ4358 and λ4047.

20. Intensity of the Satellites of the X-Ray Line $L\beta_2$. ANNA W. PEARSALL, *Central Rural School, Hamilton, N. Y.*—The relative intensities of the satellites to that of the parent line have been studied for elements of atomic weights 40 to 53 inclusive (except 43). The x-ray photographs were made with a Siegbahn vacuum spectrograph by using a calcite crystal. Microphotometer records were made from the plates with a Moll microphotometer. These records were changed to intensity curves in the usual manner and the areas integrated with a planimeter. The results are plotted with relative intensities against atomic number. This curve shows that the ratio of the intensity of satellites to that of the parent line rises from 5 percent at atomic number 40 to a maximum of 53 percent at atomic numbers in the neighborhood of 47, then falls rapidly to zero for atomic number 53. This work was done in the Physics Laboratory of Cornell University.

21. New Satellites of the X-Ray Line $L\beta_2$. S. KAUFMAN AND F. K. RICHTMYER, *Cornell University.*—New faint non-diagram lines on the short wave-length side of the $L\beta_2$ lines for the elements in the atomic number range from 73 Ta to 90 Th have been observed. The energy differences from $L\beta_2$ are greater than those of any other satellites hitherto reported but the regularity of the curves, plotting ν/R differences between the satellites and $L\beta_2$ as a function of the atomic number, suggest that these lines are associated with $L\beta_2$. There are five such new satellites found (here called $L\beta_2''' \cdots L\beta_2^{VII}$). β_2' and β_2'', the strong satellites of $L\beta_2$, have been reported before. The slopes of the respective satellite curves ($L\beta_2' \cdots L\beta_2^{VII}$) increase regularly with respect to the slope of the $L\beta_2$ line, as has been found to be the case with the L-satellites in the lower atomic number range, $40 < Z < 53$.

22. The Relative Intensities of Certain L-series X-Ray Lines of Au(79). F. K. RICHTMYER AND S. W. BARNES, *Cornell University.*—By means of a precision, two-crystal, ionization spectrometer of high resolving power, the relative intensities of the components of certain groups of lines in the L-series of Au(79) have been measured, the lines of each group being sufficiently close together on a wave-length scale so that correction for absorption in the target, tube walls, crystal, etc., is unnecessary. The results (ratio of areas) are as follows:

$$\beta_1 : \beta_2 : \beta_{15} : (\beta_2' + \beta_2'') = 100 : 48.2 : 7.2 : 5.5$$
$$\beta_4 : \beta_6 = 100 : 42.5$$
$$\beta_5 : \beta_9 : \beta_{10} = 100 : 8.8 : 5.0$$
$$\gamma_6 : \gamma_2 : \gamma_8 = 100 : 88 : 3.6$$
$$\gamma_3 : \gamma_4 = 100 : 20$$
$$\alpha_1 : \alpha_2 : (\alpha_1' + \alpha_1'' + \alpha_1''' \cdots) = 100 : 11.2 : 5.0$$

Data will be shown on the widths of these lines (full width at half maximum), which widths vary from 0.6 X.U. for γ_6 to 2.0 X.U. for β_4. Special attention should be called to the data for the satellite groups $\beta_2' + \beta_2''$ and $\alpha_1' + \alpha_1'' + \alpha_1''' \cdots$, the latter group consisting, perhaps, of five satellites, only partially resolved. The lines β_9 and β_{10} are quadrupole lines.

Saturday Morning at 10:00 O'clock

Room 329

(For simultaneous session of the Optical Society, Room 428, see Program, pages 6–7.)

Papers Nos. 23 and 29 will be read by title.

23. Tone Analysis and Physical Characteristics of Violins. II. R. B. Abbott and T. H. Stevens, *Purdue University.*—This abstract covers the work on *Tone Analysis and Physical Characteristics of Violins* since the June meeting of the Physical Society in Chicago. (See Phys. Rev. **44**, 321 (1933), abstract 33.) Musical terms used by violinists, namely, color, response and carrying power, to express relative values in violins are found to correspond to the physical quantities, quality and efficiency. Quality deals with the distribution and relative power of the partial tones, and efficiency of radiation is found to be closely related to response and carrying power. By using a standard source of sound for calibration purposes and a constant energy input, the authors have measured the relative efficiencies and qualities of violins ranging from poor to very good, by means of a cathode-ray oscillograph. The carrying power was measured by finding the distance in an open field which reduces the sound to the threshold of audibility. The results indicate that the relative values of violins can be determined by physical measurements, and that standard units for such measurements can be established.

24. Further Studies on the Double Refraction of Interfacial Layers of the Normal Aliphatic Acids. Allen King, *Institute of Applied Optics, University of Rochester, Rochester, New York.* (*Introduced by A. M. Taylor.*)—The fact that the layer of a normal fatty acid just above its melting point exhibits a measurable birefringence has been demonstrated.* The results for lauric and myristic acids indicated a definite positive value of this quantity, whereas that for undecylic acid was weakly negative. Measurements on tridecylic and palmitic acids have now been completed. They verify the previous results.

* Taylor and King, J.O.S.A. **23**, 308 (1933).

25. A Graphical Method for Obtaining the Optical Constants of a Medium from the Reflecting Powers at Several Angles of Incidence. Richard Tousey, *Harvard University.*—For a smooth surface the reflecting power, R, at any angle of incidence, i, is related by a complicated formula to the refractive index, n, and the extinction coefficient, k, for incident light of given polarization. By fitting a curve calculated from this formula to an experimental curve for R *vs.* i, n and k have been determined. A graphical method is here presented by which this fitting may be quickly done. The method can be extended to give the state of polarization of the incident light in addition to n and k. The curves involved have been computed chiefly for reflection conditions likely to occur in the extreme ultraviolet.

26. An X-Ray Study of the Structure of Benzene, Cyclohexane and Their Mixtures. Herbert K. Ward, *The Pennsylvania State College.* (*Introduced by Wheeler P. Davey.*)—The x-ray diffraction peaks of carefully purified benzene and cyclohexane and their mixtures were investigated by using Soller type slits and balanced filters. The ionization current was measured directly on a galvanometer (sensitivity 1.3×10^{-8} amperes per division) amplified by an F.P. 54 tube using a special circuit which gave a sensitivity of 6×10^{-16} amperes per division on the galvanometer. Existing data on the location of the peaks of pure benzene and of pure cyclohexane were confirmed (4.68A and 5.09A, respectively). Mixtures of the two show separate peaks for the benzene and cyclohexane whose positions correspond to those of the pure liquids and whose heights correspond with the proportions used. This is interpreted as indicating an emulsion type of mixture. Since no Tyndal effect was noticeable, the size of the droplets of the emulsion must have been very small. The x-ray data indicate between 10 and 100 molecules per droplet diameter.

27. Crystal Structure of Ammonium Uranyl Acetate. I. Fankuchen, *Cornell University.*—Ammonium uranyl acetate is tetragonal, $a=13.79$A, $c=27.60$A. This corresponds to an axial ratio of 1.414 as compared to the reported value 1.4124. The x-ray density is 2.33 as compared to reported value of 2.219. The lattice is body centered. There are 16 molecules to the unit cell. The space group is probably I4, 2 (D_4^{10}).

28. Stress Analysis by X-Ray Diffraction. C. S. Barrett and M. Gensamer, *Metals Research Laboratory, Carnegie Institute of Technology.*—Precision back reflection x-ray photograms have been used by Sachs and Weerts (Zeits. f. Physik **64**, 344 (1930)) and by Wever and Möller (Archiv. f.d. Eisenhüttenwesen **5**, 215 (1931)) to measure internal stresses in metals. Their calculations give the *sum* of the two principal stresses in the plane of the surface, but not the individual stresses nor their direction. We have developed a mathematical analysis for the case of the incident beam falling perpendicularly upon the metal surface, in which a measurement of the maximum and minimum diameters of a non-circular Debye ring yields the magnitude and direction of each of the two principal stresses in the plane of the surface. Unfortunately, the Debye rings have so little eccentricity that we have been unable to apply this analysis to metals because the width of the diffraction lines has prevented sufficiently accurate measurement of their diameters.

29. X-Ray Determination of the Chemical Composition of Oxide-Coated Cathodes. WILLIAM P. JESSE, *Research Laboratory, General Electric Company, Schenectady, N. Y.*—Satisfactory x-ray powder photographs have been obtained from oxide-coated cathodes enclosed in very thin-walled glass bulbs. Various mixtures of $BaCO_3$ and $SrCO_3$ on pure nickel ribbon ($35\times\frac{1}{2}$ mil) were transformed into the oxides and, after proper vacuum precautions, the containing bulbs were sealed off from the pump. The chemical changes in the coatings were determined from x-ray photographs (copper radiation) after successive heatings of the filament under varying temperature conditions. A summary of the results is as follows: (a) When heated to approximately 800°C, the carbonates of the mixtures are transformed into the individual oxides, BaO and SrO. (b) Further heating at approximately 960°C results in a slow transformation into a solid solution BaO–SrO. At higher temperatures this reaction is more rapid. (c) Calibration photographs from various coatings of known composition show that the BaO–SrO solid solution follows closely Vegard's Law. With such a calibration, it becomes possible to determine within two percent the relative proportions of BaO and SrO at any time during the life history of a particular filament. These results are in general agreement with the work of Burgers (Zeits. f. Physik **80**, 322 (1933)).

30. Space Charge Grid Tube with Variable Mu Grid. WALTER DEHLINGER, *Hygrade Sylvania Corporation, Emporium, Pennsylvania.*—Solutions of the generalized equations of the variable Mu triode $\exp(pv)=\int_{z_0}^{\infty}(v+z)^k \times F(z)(dx/dz)dz$ and $(v+z_0)^n=\int_{z_0}^{\infty}(v+z)^k F(z)(dx/dz)dz$ for dx/dz are given by means of the gamma function. Here Z is the reciprocal of the amplification constant, X is the axial distance along the grid, V is the ratio of grid to plate voltage and K is the space charge constant, usually 3/2. The constant n or p determines the shape of the plate current, grid voltage curve desired. The only restrictions for the values of n and k are $n>k>0$, and $\Pi(n-k-1)\neq\infty$. The solution of the integral equation of the space charge grid tube is reduced to that of the triode by a process of summation. Graphical methods are developed by means of which the distribution of grid pitches can be determined from the solution of the integral equation.

31. Laboratory Applications of Kathetrons. PALMER H. CRAIG, *Invex Corporation, Cincinnati, Ohio.*—The Kathetron (a grid controlled, mercury vapor rectifier) has been previously described (cf.: Electronics, 70–72, March, (1933)). Its use in the laboratory field has been expanded to include rheostatic control of loads from a few milliamperes, by using miniature Kathetrons, up to loads of 100 kilowatts with a single 15 ampere tube. The output current through the load is varied from zero to maximum by means of a grid potential, the current associated with which is negligible. Other applications include voltage regulation, time delay, operation from photo-cells, inversion and frequency conversion. Graphs are shown giving the voltage regulation characteristics, and circuit diagrams and oscillograms are presented to explain the theory and operation of the tube and its associated circuits.

32. An Electrical Device for Remote Indicating, Recording and Integrating the Indications of a Float Type Fluid Meter. JOSEPH RAZEK, *University of Pennsylvania.*—The type of fluid meter in which the rate of flow is determined by the rise of a float in a vertical conical tube has recently found wide application, particularly for corrosive fluids. To provide for remote indication and integration an electrical device was developed. This consists of a long induction unit in which a rod of magnetic material, attached to the float can move, thereby inducing a coltage which varies with the float position. A suitable opposing voltage causes the induced voltage to be linearly related to the float position. Indication and recording on ordinary d.c. instruments is made possible by the use of a diode. The time integral of the float position is obtained by impressing the resultant voltage on the potential coil of an induction type watt-hour meter, whose current coil carries a constant current. The revolutions of the watt-hour meter are counted by a photo-cell and light arrangement actuating a magnetic counter through an amplifier. The whole unit is supplied by a voltage regulating transformer, or stabilizing network. Tests show that the indications of the meters and the speed of the meter disk are nearly proportional to the float position, which in turn, is proportional to the flow. This device should find application for other than fluid meter use.

SATURDAY AFTERNOON AT 2:00 O'CLOCK

Room 401

(For simultaneous session of the Optical Society, Room 428, see Program, pages 7–8.)

33. Alpha-Particle Spectra and the Geiger-Nuttall Law. ARTHUR E. RUARK, *University of Pittsburgh.*—Gamow's theory gives the relation $\log\lambda=a(r_0, j)-bE^{-\frac{1}{2}}$; λ is a decay constant, E is disintegration energy, r_0 is "nuclear radius," j is azimuthal quantum number; b depends only on universal constants and atomic number. Thus a and b should vary slowly with Z. Gamow uses λ- and E-values to obtain r_0 and j. Kurie found that plotting $\log\lambda$ against $E^{-\frac{1}{2}}$ yields straight lines. I have made such plots, showing points for all of Rosenblum's alpha-groups. The groups, α_0, α_2, α_4 of ThC lie on the line representing the average trend of the Ac family. The groups α_1, α_3 lie well off the line. This suggests reconsideration of Gamow's assignment of j values. (His computations of relative intensities contain numerical

errors.) We must look at such problems from the standpoint of transition probabilities, remembering that the potential barrier alters as the alpha-particle emerges from the nucleus. The constants a, b for the U, Th and Ac families are 70.6, 18.0: 82.3, 21.4: 74.7, 19.9. Gamow's theory yields 53.4, 14.7 if we take $r_0 = 8 \times 10^{-13}$ cm, $Z = 88$; other potential barriers are being studied in the hope of reducing this discrepancy.

34. Alpha-, Beta- and Gamma-Rays of the Actinium Family. ARTHUR E. RUARK, *University of Pittsburgh.*—Rosenblum's work on alpha-particle spectra leads to classifications of actinium family beta-rays. Also we can show that some unclassified lines are due to K-conversion, because if they were converted in any other shell we should expect strong K-conversion lines which are not observed. (1) *Pa.Ac.* Beta-ray 93.9 ekv (electron kilovolts) represents conversion of gamma-ray 94.9 ekv in the N shell. Beta-rays 245 and 257 ekv represent K-conversion of ramma-rays 3.514 and 3.64 ekv. All recorded lines are now explained. (2) *AcX.An and An.AcA.* Rosenblum found levels 115 and 190 ekv for AcX.An, and 270 and 397 ekv for An.AcA. Meitner's beta-spectrum obtained with AcX should contain lines of An.AcA. One might think her gamma-ray 268.8 ekv is due to An.AcA, but the following facts support its assignment to AcX.An: (a) the difference of this ray and the ray 153.0 ekv (certainly due to AcX.An) is 115.8, checking Rosenblum's levels: (b) the beta-ray 175.9 ekv can represent K-conversion of a gamma-ray 268.5 of An.AcA. Beta-rays 104.3 and 180.0 are best interpreted as K- and L-conversion of a ray 196.9 of An.AcA. Beta-rays at 223.0 and 236.9 must be due to K-conversion, but we cannot say in what element.

35. Ionization in Air and the Biological Effects of Gamma-Rays. G. FAILLA, *Memorial Hospital, New York.*—The experiments of Packard have shown that the same number of ions produced in free air by x-rays of different wave-lengths, kills the same percentage of fruit fly eggs, under specified conditions. Since the definition of the roentgen is based on air ionization, he has concluded that the same dose of radiation measured in roentgens produces the same biological effect, irrespective of the wave-length. By extrapolation it has been contended that the same relation would also hold for gamma-rays. A crucial experimental test has not been possible heretofore. We have now developed a method for the measurement of the actual ionization in air under the conditions in which Packard carried out his experiments with gamma-rays. The results show very definitely, that equal ionizations *in air* are not equally effective in killing fruit fly eggs in the case of x-rays and gamma-rays. The difference is much greater than any possible experimental error. This result and others obtained in the course of the work, show that the therapeutic efficacy of very high voltage x-rays and gamma-rays cannot be predicted by the usual biological and physical tests.

36. Cosmic Ray Ionization in a Heavy Walled Chamber at High Altitudes. A. H. COMPTON AND R. J. STEPHENSON, *University of Chicago.*—A recording cosmic-ray meter whose steel ionization chamber was surrounded by a spherical shell of lead shot, equivalent to 6 cm of solid lead, was carried into the stratosphere by Commander Settle and Major Fordney, up to a barometric pressure of 50.5 mm, as read from a mercury barometer. Previous tests with heavy walled chambers at an altitude of 4300 meters (barometer 447 mm) show that the screen of lead shot was sufficient to eliminate practically all transition effects due to secondary radiations excited in the air. If the cosmic rays are of the γ-ray type, i.e., exponentially absorbed, the ionization should therefore follow either the "Gold integral" curve, which takes account of their isotropic origin, or some curve which is the resultant of several such Gold integrals. The experimental ionization-depth seems to follow more nearly a simple exponential law than that represented by the Gold integral. A curve of such a shape cannot be described by a γ-ray beam of any assumed components, but is closely represented by the ionization by α-rays (i.e., ionizing particles with a definite range) having a Maxwellian distribution of energies.

37. Electrical Latent Image. V. K. ZWORYKIN, *Electronic Research Laboratory, RCA Victor Company, Inc., Camden, N. J.*—The paper deals with an apparatus capable of storing electrically the information from an optical image projected on a sort of photoelectric mosaic, and reproducing it at the desired moment. Several possible embodiments of the same idea are described. The operation, merits and limitations of each are discussed. Although the original device was developed as a pickup camera for television purposes, it can be used in the same or modified form for many other purposes. Its sensitivity in the ultraviolet and infrared part of the spectrum opens new possibilities for investigation in these regions. The device also allows a number of other interesting applications, such as the amplification of the light intensity of the image over its original value, the electrical magnification of the size of the image, and various new combinations with regular optical devices.

38. New Experiments on Bitter's Powder Patterns. K. J. SIXTUS, *Research Laboratory, General Electric Co., Schenectady, N. Y.*—On six single crystals of silicon-iron (3.5 percent Si) the properties of the powder patterns first observed by F. Bitter (Phys. Rev. **38**, 1903 (1931) and **41**, 507 (1932)) have been studied. Three different types of pattern can be distinguished: I, on the straight part of the magnetization curve at low fields, II, from the knee of the magnetization curve nearly up to saturation, III, near to and at saturation. I consists of rather broad lines which lie in the direction of intersects between (100) crystal-planes and the sample surface, II of very distinct lines, multiplying as the field is increased and parallel to intersects between (110) planes with the surface, III of broad bands in general perpendicular to the applied field. The different directions of the patterns can be explained by the present theory of the magnetization process, while for the understanding of other properties, particularly the line spacing (about 10^{-2} cm) and its field dependence, a hypothesis is suggested.

39. The Vapor Pressure of Deuterium. F. G. BRICKWEDDE, R. B. SCOTT, HAROLD C. UREY AND M. H. WAHL. *The Bureau of Standards, Washington, D. C. and Columbia University, New York, N. Y.*—The vapor pressure of a sample of deuterium, Hd_2, of nearly 100 percent purity, was measured with a mercury filled manometer connected to a bulb containing liquid or solid deuterium. The bulb of the manometer was immersed in a liquid or solid hydrogen cryostat connected with a vacuum pump for temperature regulation. Temperatures were determined with a vapor pressure thermometer filled with ordinary hydrogen. The results are as follows:

Temperature	*V.P. of* Hp_2	*V.P. of* Hd_2
14.0°K (Triple pt. of Hp_2)	5.4 cm of Hg.	0.5_8 cm of Hg
18.7° (Triple pt. of Hd_2)	$45._4$	13.
20.4° (Boiling pt. of Hp_2)	76.0	25.

Preliminary results show that the ratio of the heats of vaporization, sublimation and fusion are: 1.25, 1.46, and 1.6 respectively, the values for deuterium being larger in each case. Also, the difference in vapor pressures is larger than expected from the theory given by Urey, Brickwedde and Murphy. (Phys. Rev. 40, 1 (1932)). Additional measurements are being made with another sample of deuterium prepared from water further electrolyzed beyond that from which the above sample was prepared.

40. Raman Spectrum of Heavy Water. R. W. WOOD, *The Johns Hopkins University.* Raman spectra of 18 and 80 percent heavy water have been obtained by Hg 2536 excitation. H^2OH^2 gives a Raman band of much shorter wave-length than ordinary water. H^2OH^1 gives two bands, one nearly but not quite in coincidence with the bank just mentioned and another nearly in coincidence with the band of ordinary water. Heavy water vapor should show two double lines corresponding to the partially superposed bands.

41. Small Angle Scattering of Potassium Atoms. W. H. MAIS AND I. I. RABI, *Columbia University.*—A narrow beam of neutral potassium atoms was scattered by six different gases. The scattering was investigated by means of a surface-ionization detector. The detecting filament subtended an angle of approximately 4′. From the ratio $I/I_0 = e^{-d/\lambda}$ one can calculate by a method analogous to Tait's an effective collision radius for scattering greater than 4′. If we include in I all potassium atoms which are scattered less than 1° we obtain another set of collision radii. These two sets of values are presented in the table together with the σ_{12} obtained by using 3A for the radius of the potassium atom and the kinetic theory radii for the gases. If we are to take account of the quantum theory scattering of hard spheres which gives a tremendous preference to small angle scattering we should multiply the kinetic theory radii by about 1.5. It is then evident that except in the case of hydrogen and helium, the hard sphere picture is not sufficient to account for the scattering at very small angles.

Gas	σ_{12} in A angle = 4′	σ_{12} in A angle = 1°	σ_{12} in A Kinetic Theory
H_2	7.2	5.7	4.18
He	6.9	5.0	3.95
Ne	8.7	6.0	4.20
N_2	12.5	7.3	4.64
A	11.3	8.8	4.49
CO_2	13.3	9.6	4.78

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session in Room 401 after the completion of the regular program for the session.

42. Deflection of Cosmic Ray Secondaries in Magnetized Iron. W. F. G. SWANN AND W. E. DANFORTH, JR., *The Bartol Research Foundation.*—A mathematical analysis by one of us (W.E.D.), taking into account counter sizes and distances, has shown that the results of L. M. Mott-Smith's experiments on deviation of cosmic rays by magnetized iron are not inconsistent with the assumption that magnetic induction is the fundamental vector operative to cause the deflection. The said experiments, however, appear inconclusive for a decision of the point. We have repeated these deflection experiments under conditions which take account of the geometrical considerations involved and of the energy loss of the particles in the iron. In the actual experiments a 7.8 percent decrease of counting rate was observed with a probable error of 1 percent. On the assumption that the magnetic induction B is the vector involved, the results can be explained on the assumption that those rays having energy greater than that necessary to penetrate the iron (4.5×10^8) have an "effective" energy of 1.9×10^9. On the other hand, the assumption that the magnetic intensity H is the vector concerned would point to an energy much less than that necessary to penetrate the iron.

43. Comments on the analysis of an intensity complex with special reference to that of $H\alpha$. R. C. WILLIAMS AND R. C. GIBBS, *Cornell University.*—Any analysis based solely on a microphotometer curve of a photographic record of a complex is in general quite unreliable, especially when it is necessary to take into account any shift in the spectral position of a maximum caused by overlapping components. Such a procedure will yield results that will vary widely with exposure conditions. Reduction of microphotometer curves to intensity curves by means of suitable intensity marks, preferably on the same plate, is necessary if precise quantitative results are to be obtained. Examples are given to show that the practice often followed of treating the "center of gravity" of even a fairly symmetrical complex and its position of maximum intensity as identical is unsound. The latter, but not the former, depends upon the shape or half-line width. For example, in the low-frequency member of the H^1_α "doublet," consisting of three components and often treated as symmetrical, the shift of the theoretical center of gravity from the main component is .006 cm^{-1}, whereas for the same component intensities and positions and a half-line-width of .180 cm^{-1} which is easily obtainable, the displacement of the maximum intensity from this component is only .003 cm^{-1}. Generalized formulae, useful in checking empirical analyses, are given for finding both the center of gravity and the position of a maximum or minimum intensity, relative to any chosen component, of an intensity complex composed of any number of similar and perfectly symmetrical components with given intensities, positions and shape.